Orthopaedics & Traumatology: Surgery & Research 101 (2015) 539–542

Available online at

ScienceDirect

www.sciencedirect.com

Elsevier Masson France

EM|consulte

www.em-consulte.com/en

Original article

Muscle recovery after ACL reconstruction with 4-strand semitendinosus graft harvested through either a posterior or anterior incision: A preliminary study

D. Dujardin , N. Fontanin , A. Geffrier , N. Morel , C. Mensa , X. Ohl *

Service de chirurgie orthopédique et traumatologique, CHU Maison-Blanche, 45, rue Cognacq-Jay, 51092 Reims, France

ARTICLE INFO

Article history:
Received 3 October 2014
Accepted 2 March 2015

Keywords:
Anterior cruciate ligament reconstruction
Muscle strength
Quadriceps muscle
Hamstring muscle
Isokinetic strength testing
Posterior harvesting

ABSTRACT

Introduction: Harvesting of a 4-strand semitendinosis (ST4) graft during anterior cruciate ligament (ACL) reconstruction can be performed through either a posterior or anterior approach. The objective of this study was to evaluate the recovery of the quadriceps and hamstring muscles as a function of the graft harvesting method. We hypothesized that posterior harvesting (PH) would lead to better recovery in hamstring strength than anterior harvesting (AH).
Methods: In this prospective study, the semitendinosus was harvested through an anterior incision in the first group of patients and through a posterior one in the second group of patients. The patients were enrolled consecutively, without randomization. Isokinetic muscle testing was performed three and six months postoperative to determine the strength deficit in the quadriceps and hamstring muscles of the operated leg relative to the uninjured contralateral leg.
Results: Thirty-nine patients were included: 20 in the AH group and 19 in the PH group. The mean quadriceps strength deficit after three and six months was 42% and 26% for AH and 29% and 19% for the PH, respectively ($P = 0.01$ after three months and $P = 0.16$ after six months). The mean hamstring strength deficit after three and six months was 31% and 17% for AH and 23% and 15% for the PH, respectively ($P = 0.09$ after three months and $P = 0.45$ after six months). After three months, the PH group had recovered 12% more quadriceps muscle strength than the AH group ($P = 0.03$).
Conclusion: Our hypothesis was not confirmed. Harvesting of a ST4 graft for ACL reconstruction using a posterior approach led to better muscle strength recovery in the quadriceps only after three months.
Case control study: Level 3.

1. Introduction

Anterior cruciate ligament (ACL) rupture is a common sports injury. Although ACL reconstruction performed with a hamstring graft is a reliable technique, knee flexion strength is reduced in the postoperative phase [1–3]. To minimize this negative effect, surgeons can choose to harvest only the semitendinosus and leave the gracilis intact [4]. This corresponds to the 4-strand semitendinosus (ST4) technique where the tendon graft is harvested either through the standard anterior approach (AH) or a minimally invasive posterior approach (PH) in the popliteal fossa [5,6]. The purpose of this study was to compare the strength of the hamstring and quadriceps muscles as a function of the harvesting method after ACL reconstruction with a ST4 graft. We hypothesized that posterior hamstring harvesting will result in less loss of flexion force in the hamstring muscles after surgery.

2. Material and methods

2.1. Study design and patient population

This was a single-center, prospective study performed between September 2011 and May 2014 at the Orthopedic Surgery Department of the Reims (France) University Hospital Center in patients undergoing ACL reconstruction with an ST4 graft. All patients consented to participating in this study. The patients were enrolled consecutively into the study, without randomization.

Patients were included if they were above 18 years of age, participated in a pivoting sport (with or without contact), had a complete ACL rupture confirmed on MRI, had measurable instability or

* Corresponding author.
E-mail address: xohl@chu-reims.fr (X. Ohl).

http://dx.doi.org/10.1016/j.otsr.2015.03.017
1877-0568/

anterior laxity (defined as 3 mm difference relative to healthy side) on the KT 1000™ arthrometer (MEDmetric® Corporation, San Diego, CA) and had no previous surgery on the injured knee.

Patients were excluded if the collateral ligaments were injured, the ACL was partially torn, a cartilage injury was present or a fracture occurred in combination with the ACL injury. The presence of a meniscus injury was not grounds for exclusion: 50% of patients in the AH group had a meniscus injury and 63% in the PH group.

The graft was harvested through the classical anterior approach on patients operated between September 2011 and September 2012. The graft was harvested through a posterior approach in the patients operated between September 2012 and November 2013. One surgeon performed all the procedures.

2.2. Surgical technique

The ACL was repaired arthroscopically with the ST4 using an all-inside technique with double endobuttons (GraftLink® technique, Arthrex, Naples, FL, USA).

In the anterior harvesting group, a short incision was made three finger widths below the pole of the patella and two finger widths medial to it. The sartorius aponeurosis over the semitendinosus and gracilis was opened along healing lines to expose the upper portion of the semitendinosus. An open smooth stripper was used to harvest the entire semitendinosus muscle-tendon unit, which was cut at its bone attachment.

In the posterior harvesting group, the hamstring tendons were palpated in the medial and distal part of the popliteal fossa. A 2-cm horizontal incision was made immediately below the posterior knee fold. The fascia surrounding the ST was opened and the ST externalized. After cutting any adhesions, an open stripper was used to harvest the ST up to its myotendinous junction. Any remaining muscle fibers were removed from the tendon, which was then cut at its tibial insertion with a closed stripper.

The postoperative rehabilitation protocol was the same in both groups. It was suggested that patients undergo three rehabilitation sessions per week. The first phase of rehabilitation was three months long and consisted of partially protected weight bearing with a hinged splint for 30 days with unlimited passive knee mobilization and closed kinetic chain exercises. The second phase started after three months and consisted of quadriceps and hamstring strengthening in combination with open kinetic chain and proprioceptive exercises.

2.3. Isokinetic testing

Isokinetic testing was performed on an isokinetic testing machine (Con-Trex® – Medimex, Sainte-Foy-les-Lyon, France) by a rehabilitation physician. The main contraindications to isokinetic testing were the presence of an infection, greater than 20° flexion deformity and/or less than 100° knee flexion range, pain on VAS of ≥ 5/10, thigh muscle inhibition or unstable cardiovascular disease.

The patient warmed up for the testing by pedaling for 10 minutes on a stationary bicycle (submaximal effort). The isokinetic test protocol consisted of concentric/concentric testing of the knee flexors and extensors over three sets of trials separated by one minute rest: warm up and movement practice for five submaximal contractions at 240°/s; five maximal contractions at 240°/s; three maximal contractions at 60°/s with verbal encouragement. Either the operated or non-operated side was tested first, with the other side being done immediately after. The measured value was the peak moment (N/m) in the best of the three repetitions at 60°/s for the knee flexors and extensors. In this series, the test was considered valid if no pain was induced by the test and the coefficient of variation in the peak moments was ≤ 10%.

Table 1
Preoperative and intraoperative data for both groups.

Variables	AH ($n = 20$)	PH ($n = 19$)	P value
Age (years)	28 ± 8.2	24 ± 6.7	n/s
Female	8 (40%)	6 (32%)	n/s
Subjective IKDC score (100 max)	42	47	n/s
Time to surgery (months)	5.1 ± 3.3 (2–12)	4.1 ± 2.7 (1–12)	n/s
Preoperative laxity (mm)	7.3 ± 2.1	7.5 ± 1.2	n/s
Operative time (min)	84 ± 15	74 ± 19	n/s
Lateral meniscus injury	$n = 3$ 3 meniscectomy	$n = 6$ 5 meniscectomy 1 repair	n/s
Medial meniscus injury	$n = 7$ 3 meniscectomy 4 repair	$n = 6$ 5 meniscectomy 1 repair	n/s

AH: anterior harvesting; PH: posterior harvesting; n/s: not significant.

2.4. Data collection

The following preoperative and intraoperative data were collected: time between injury event and surgery, preoperative laxity (measured with KT 1000™ arthrometer), subjective IKDC score, operative time, diameter of graft used.

The following postoperative data were collected: joint range of motion, thigh circumference (10 cm above the patella), and complications.

The primary outcome measure was the quadriceps and hamstring strength deficit in the operated leg relative to the contralateral side at three and six months postoperative.

2.5. Statistical analysis

Quantitative variables were described by their mean and standard deviation values. Qualitative variables were described by their frequency and corresponding percentage. The groups were compared with Student's t-test for quantitative variable and the Chi^2 or Fisher's exact test for qualitative variables. The mean deficit in quadriceps and hamstring muscle activity was calculated for each group at the 3- and 6-month time points. An analysis of the strength deficit as a function of the harvesting technique was performed using an age-adjusted, generalized linear regression model. All statistical tests were performed with the SAS 9.2 software (SAS Institute, Cary, NC). The significance threshold was set a 0.05.

3. Results

3.1. Study population

Thirty-nine patients were included, 20 in the AH group and 19 in the PH group. The characteristics of the two groups and the clinical examination results at three and six months postoperative are given in Tables 1 and 2. The two groups were statistically comparable in terms of their preoperative characteristics and 3-month and 6-month clinical data (time to surgery, pain, quadriceps atrophy, flexion deformity, range of motion). Patients who underwent anterior graft harvesting were operated on for a mean of 84 minutes and those who underwent posterior harvesting were operated on for a mean of 74 minutes (difference not statistically significant).

Table 2
Clinical outcomes 3 and 6 months postoperative.

Clinical exam	AH	PH	*P* value
3 months			
VAS	1.5	1.1	n/s
Mean flexion	127° ± 11	130° ± 0	n/s
Flexion deformity > 5 degrees	2 (10%)	1 (5%)	n/s
Mean atrophy relative to contralateral side (cm)	2.7	2	n/s
6 months			
VAS	0.6	0.4	n/s
Mean flexion	131° ± 7	134° ± 5	n/s
Flexion deformity > 5 degrees	0	0	n/s
Mean atrophy relative to contralateral side (cm)	2	1.6	n/s

AH: anterior harvesting; PH: posterior harvesting; n/s: not significant; VAS: Visual Analog Scale.

3.2. Complications

No serious complications such as infection or early graft rupture were observed. Two patients in the AH group experienced hypoesthesia on the anterior side of their operated knee.

3.3. Isokinetic testing

The mean strength deficits for the quadriceps and hamstring muscles after three and six months are given in Table 3. The quadriceps strength deficit in the PH group (29%) was less than the one in the AH group (42%) after three months ($P = 0.03$). The hamstring strength deficit after three months was similar between groups ($P = 0.09$). After six months, the strength deficit in the quadriceps and hamstring did not differ between groups.

4. Discussion

This study found a lesser strength deficit three months postoperative in the quadriceps muscles of the group that underwent posterior graft harvesting. Conversely, the harvesting method did not significantly affect the strength recovery in the hamstring muscles three and six months postoperative. Our hypothesis was not confirmed. The reasons for better recovery of quadriceps muscle strength after posterior harvesting of an ST4 graft during ACL reconstruction are not clear.

The better recovery of strength in the PH group three months after surgery can be explained by less quadriceps muscle inhibition due to the preservation of the sartorius attachment. Hart et al. [7] found that the greatest quadriceps activation failure exists in patients with the most severe knee incursion, either due to trauma or surgery. Harvesting the hamstring graft through a posterior approach is consistent with the principle of preserving the knee's biological environment, thus could explain the better quadriceps muscle recovery. Konishi and Fukubayashi [8] demonstrated a relationship between muscle volume and muscle torque of the quadriceps after anterior cruciate ligament reconstruction. In the current study, there was no significant difference between the two groups in terms of the measured thigh muscle volume.

Table 3
Mean strength deficit relative to uninjured side (percentage).

	AH	PH	*P* value
3 months			
Quadriceps	42 (± 14)	29 (± 15)	0.01
Hamstrings	31 (± 13)	23 (± 13)	0.09
6 months			
Quadriceps	26 (± 16)	19 (± 12)	0.16
Hamstrings	17 (± 15)	14 (± 11)	0.45

AH: anterior harvesting; PH: posterior harvesting.

There was a non-significant trend towards the PH having less hamstring muscle deficiency than the AH group after three months. The low statistical power in this study may explain why this difference is not significant. There were no significant differences between groups 6 months postoperative in either the hamstring or quadriceps strength. Janssen et al. [9] found signs of gracilis muscle regeneration after ACL reconstruction, which could explain the minimal impact of posterior harvesting on muscle strength in the medium and long term. Conversely, Kyung et al. [4] found that the hamstring muscle deficit after two years was less if only the ST muscle was harvested, as opposed to the typical harvesting of the semitendinosus and gracilis muscles.

Other factors typically put forth to explain differences in isokinetic testing results were not a decisive factor in this study. The time between the injury and surgical procedure is known to affect the results of the isokinetic testing: the greater the wait before the procedure, the lower the patient's postoperative strength [10]. In the current study, this wait was similar between the two groups, but we had no preoperative isokinetic testing data. Nicholas et al. [11] found that postoperative strength was not affected when the procedure with tourniquet lasted for less than 114 minutes. Thus, the extra 10 minutes with tourniquet for the anterior harvesting procedure would have had no effect on the postoperative strength levels. The pain (VAS) after three and six months was similar between groups, thus cannot explain these differences [12].

Six months after ACL reconstruction, good functional and isokinetic test results are determined by age and the presence of cartilage lesions, which affect muscle strength [13]. In the current study, the two groups of patients had the same mean age and any patients with cartilage damage were excluded from the study. Lepley et al. [14] looked into the relationship between meniscus surgery during ACL reconstruction and the recovery of quadriceps function. Three groups were compared: ACL reconstruction only, ACL reconstruction with meniscectomy, ACL reconstruction with meniscus repair. The recovery of muscle function did not differ between groups.

The posterior harvesting technique used in our study is different from the one initially described by Prodromos et al. [6,15]. In our series, the horizontal incision is more distal, below the posterior knee fold [5]. The ST is harvested directly through the posterior incision with a closed tendon stripper without making an anterior counter-incision. A small anterior slit is made in the skin to pass the burr needed for the tibial tunnel. In the technical description of the posterior harvesting technique by Prodromos [6], 80% of patients said that their knee had a better appearance after posterior harvesting, and most patients said that the appearance of their knee after surgery was important to them.

Comorbidities associated with patellar tendon harvesting in comparison to standard anterior hamstring harvesting are well known [1,3,10,16] and consistent with the goal of preserving the biological environment to improve postoperative recovery. Posterior hamstring harvesting is consistent with this logic. Known advantages of posterior harvesting [6,15,17] consist of better appearance due to the nearly invisible incision in the popliteal fossa that has a lower risk of wound dehiscence; faster harvesting due to the hamstring tendons being easier to identify; less risk of harvesting a graft that is too short; fewer nerve injuries (infrapatellar branch of the saphenous nerve) [18]; no detachment of the sartorius. Together these also lead to satisfactory results in terms of postoperative knee stability.

Our study has a certain number of methodological biases that can explain the unexpected results. The patients were enrolled consecutively into the study, without randomization. The small

patient population in this study reduced its statistical power and made it impossible to detect small differences in hamstring muscle strength. Although the same rehabilitation protocol was prescribed at the consultation and upon discharge, the protocol was carried out by independent physical therapists who did not have equal access to technical features. The quality of the rehabilitation after ACL reconstruction is known to affect the postoperative isokinetic testing results [10,19]. Finally, we had no preoperative data showing the strength in the hamstring and quadriceps relative to the uninjured contralateral side.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References

[1] Ageberg E, Roos HP, Silbernagel KG, et al. Knee extension and flexion muscle power after anterior cruciate ligament reconstruction with patellar tendon graft or hamstring tendons graft: a cross-sectional comparison 3 years post-surgery. Knee Surg Sports Traumatol Arthrosc 2009;17:162–9, http://dx.doi.org/10.1007/s00167-008-0645-4.

[2] Condouret J, Cohn J, Ferret JM, et al. [Isokinetic assessment with two years follow-up of anterior cruciate ligament reconstruction with patellar tendon or hamstring tendons]. Rev Chir Orthop Rep Appar Mot 2008;94:375–82.

[3] Li S, Su W, Zhao J, et al. A meta-analysis of hamstring autografts versus bone-patellar tendon-bone autografts for reconstruction of the anterior cruciate ligament. Knee 2011;18:287–93.

[4] Kyung HS, Lee HJ, Oh CW, Hong HP. Comparison of results after anterior cruciate ligament reconstruction using a four-strand single semitendinosus or a semitendinosus and gracilis tendon. Knee Surg Sports Traumatol Arthrosc 2014, http://dx.doi.org/10.1007/s00167-014-3076-4 [Epub ahead of print].

[5] Letartre R, Isida R, Pommepuy T, Miletic B. Horizontal posterior hamstring harvest. Orthop Traumatol Surg Res 2014;100:959–61.

[6] Prodromos CC. Posterior mini-incision hamstring harvest. Sports Med Arthrosc 2010;18:12–4.

[7] Hart JM, Pietrosimone B, Hertel J, Ingersoll CD. Quadriceps activation following knee injuries: a systematic review. J Athl Train 2010;45:87–97.

[8] Konishi Y, Fukubayashi T. Relationship between muscle volume and muscle torque of the hamstrings after anterior cruciate ligament reconstruction. J Sci Med Sport 2010;13:101–5.

[9] Janssen RP, van der Velden MJ, Pasmans HL, Sala HA. Regeneration of hamstring tendons after anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc 2013;21:898–905.

[10] Xergia SA, McClelland JA, Kvist J, et al. The influence of graft choice on isokinetic muscle strength 4–24 months after anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc 2011;19:768–80.

[11] Nicholas SJ, Tyler TF, McHugh MP, Gleim GW. The effect on leg strength of tourniquet use during anterior cruciate ligament reconstruction: a prospective randomized study. Arthroscopy 2001;17:603–7.

[12] Dauty M, Tortelier L, Huguet D, et al. [Consequences of pain on isokinetic performance after anterior cruciate ligament reconstruction using a semitendinosus and gracilis autograft]. Rev Chir Orthop Rep Appar Mot 2006;92:455–63.

[13] Krych AJ, Woodcock JA, Morgan JA, et al. Factors associated with excellent 6-month functional and isokinetic test results following ACL reconstruction. Knee Surg Sports Traumatol Arthrosc 2015;23:1053–9, http://dx.doi.org/10.1007/s00167-014-2869-9.

[14] Lepley LK, Wojtys EM, Palmieri-Smith RM. Does concomitant meniscectomy or meniscal repair affect the recovery of quadriceps function post-ACL reconstruction? Knee Surg Sports Traumatol Arthrosc 2014, http://dx.doi.org/10.1007/s00167-014-3093-3 [Epub ahead of print].

[15] Prodromos CC, Han YS, Keller BL, Bolyard RJ. Posterior mini-incision technique for hamstring anterior cruciate ligament reconstruction graft harvest. Arthroscopy 2005;21:130–7.

[16] Shaerf DA, Pastides PS, Sarraf KM, Willis-Owen CA. Anterior cruciate ligament reconstruction best practice: a review of graft choice. World J Orthop 2014;5:23–9.

[17] Wilson TJ, Lubowitz JH. Minimally invasive posterior hamstring harvest. Arthrosc Tech 2013;2:e299–301.

[18] Roussignol X, Bertiaux S, Rahali S, et al. Minimally invasive posterior approach in the popliteal fossa for semitendinosus and gracilis tendon harvesting: an anatomic study. Orthop Traumatol Surg Res 2015;101:167-172, http://dx.doi.org/10.1016/j.otsr.2014.12.009.

[19] Eitzen I, Holm I, Risberg MA. Preoperative quadriceps strength is a significant predictor of knee function two years after anterior cruciate ligament reconstruction. Br J Sports Med 2009;43:371–6.